Space Weather Technical Forecast

Issued on Saturday 4 January 2025 at 01:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely, with an increased chance of X-class flares. Chance G1 Minor Geomagnetic Storms Days 1-2 (04-05 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity increased to High levels with an X1.2 flare observed at 03/1139 UTC and a dual portion X1.1 flare observed at 03/2241UTC, both flares from AR3947 in the northeast disk. This region also looks responsible for a M5.8 flare at 03/2356 UTC.

There are fourteen sunspot regions on the Earth-facing disc, with AR3949 now attributed to a small bipolar region in the southwest, AR3935 disappeared from view towards the west limb and a new unnumbered region rounding the southeast limb. Despite the large number of spots on the facing-disc, many are small and magnetically simple. Of the more notable regions, AR3947, responsible for the recent flare activity, continues to develop and has tentatively acquired a delta spot in its moderately sized leading portion. Some slight decay of AR3944 and AR3945 has taken place, otherwise there has been little change to the remaining regions on the facing-disc.

The CME associated with the X1.2 flare observed at 03/1139 UTC has been assessed as non-Earth directed. Further CMEs associated with the recent flaring from the same region will be analysed as they appear in coronagraph imagery, with ejecta clearly associated with the most recent X1.1 flare in SUVI imagery, this event also produced a type II radio burst with an assessed speed of 454km/s.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, have shown a generally steady decline from 460km/s towards 400km/s in the period, but with a recent uptick to 430km/s. Density was predominantly at average to below average levels, but with a generally above average period (peaking 27ppcc) between 03/0230-0500 UTC. The Interplanetary Magnetic Field, Bt, has been largely moderate. The north-south component, Bz, persistently weak to moderately positive though much of the period. The Phi angle changed steadily from initially positive (away from the Sun), to become negative (towards the Sun) from around 03/1200UTC.

Geomagnetic activity at Quiet to Unsettled levels.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 04/0000 UTC fluence observation was 2.85e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Activity is forecast to be Moderate to High, with isolated M-class flares considered likely and a chance of further isolated X-flares. This risk increased given recent activity from AR3947.

Solar Wind / Geomagnetic Activity: There is one potential Earth directed CME, which is expected to pass near Earth early on Day 1 (04 Jan), perhaps already being experienced. A large coronal hole is expected to bring an onset of faster solar winds during the later half of Day 1 (04 Jan) or into Day 2 (05 Jan). Elevated solar winds of 500-600km/s are likely, declining only slowly into Days 3 and 4 (06-07 Jan).

Geomagnetic activity is expected to be Quiet to Unsettled initially, with a chance of Active intervals and a slight chance of a G1 Minor geomagnetic storm early on Day 1 (04 Jan) in association with glancing CME arrival. Unsettled to Active conditions are then expected with a chance G1 Minor geomagnetic storm intervals during the later half of Day 1 (04 Jan) or into Day 2 (05 Jan) with HSS onset. Activity is forecast to subside to generally Quiet to Unsettled levels into Days 3 and 4 (06-07 Jan).

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to continue at background levels, but with a slight chance of exceeding the S1/Minor Storm threshold. GOES16 high energy electron flux may increase briefly after recent CME activity, before further solar wind enhancement from later Day 1 or Day 2 (04 and 05 Jan) likely suppresses values again. The associated fluence is expected to remain below the Active threshold throughout.

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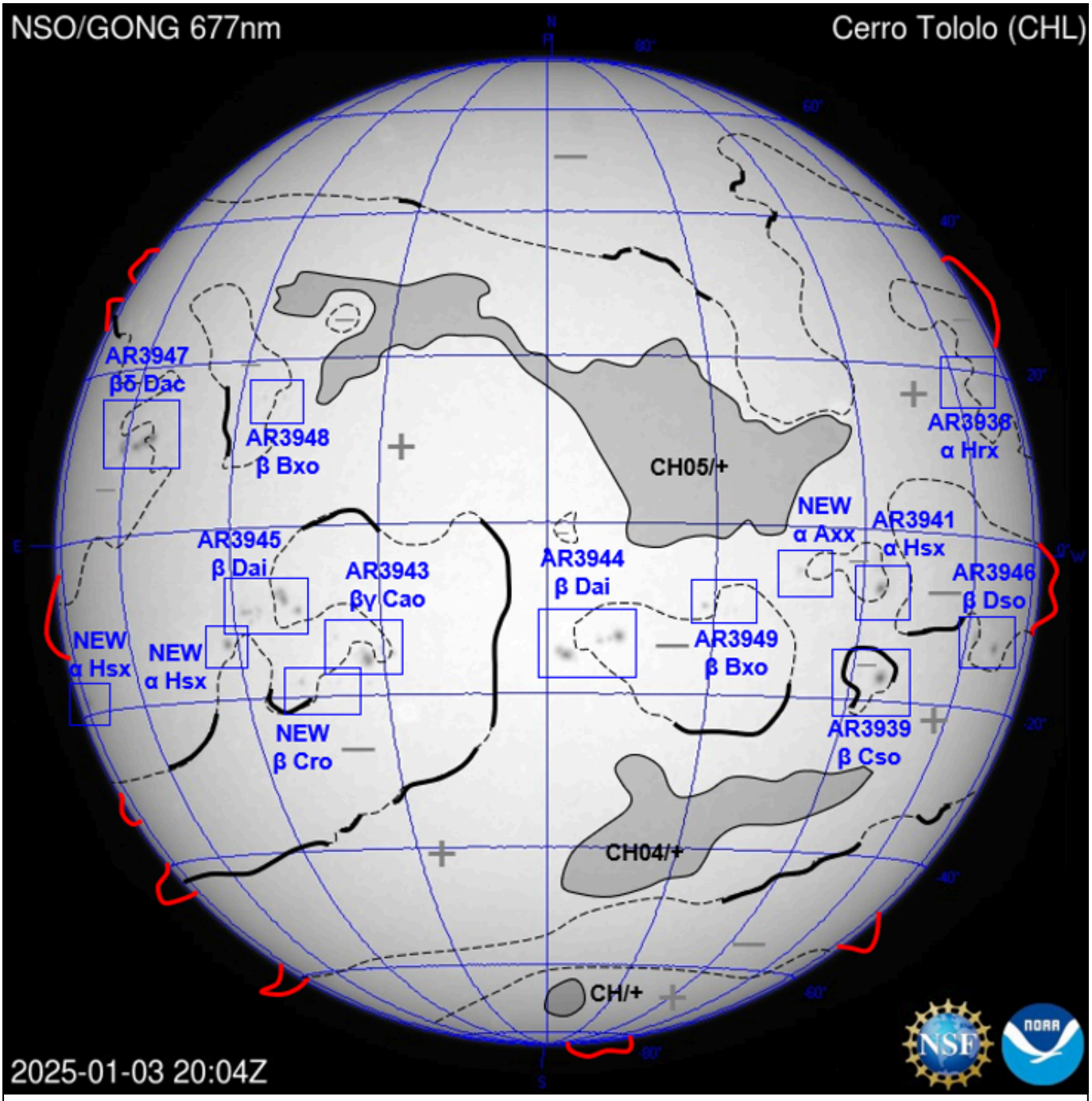
Figure 1: Solar Synoptic Map Valid 03/2000 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There is one potential Earth directed CME, from a weak filament eruption early on 01 Jan from the vicinity of AR3939. This is expected to pass close to Earth early on Day 1 (04 Jan), only glancing effects anticipated, perhaps already being experienced, which may bring briefly elevated solar winds.

There are two notable coronal holes on the Earth-facing disc, CH04+ in the south, and CH05+ in the north. The most likely of these to have an influence on Earth is CH05+. This is a persistent feature, although on its previous rotation covered a smaller area and was further to the solar east. Solar wind speeds associated with the feature reached 500-550km/s, giving Active geomagnetic intervals. Given the current location of CH05/+, the anticipated connection to the high speed stream from CH05+ may arrive slightly earlier than the last rotation, with an onset of faster solar wind expected during the later half of Day 1 (04 Jan) or into Day 2 (05 Jan). Elevated solar winds of 500-600km/s are likely, declining only slowly into Days 3 and 4 (06-07 Jan). This is broadly supported in MOSWOC ENLIL output.

Geomagnetic activity is expected to be Quiet to Unsettled initially, with a chance of Active intervals and a slight chance of a G1 Minor geomagnetic storm early on Day 1 (04 Jan) in association with glancing CME arrival. Unsettled to Active conditions are then expected with a chance G1 Minor geomagnetic storm intervals during the later half of Day 1 (04 Jan) or into Day 2 (05 Jan) with HSS onset. Activity is forecast to subside to generally Quiet to Unsettled levels into Days 3 and 4 (06-07 Jan).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	30	30	5	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
01/0740	Partial	Filament	SW	560	04/0100 UTC	Low confidence in any arrival as expected to be a glancing impact at best.

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Radio Blackouts - X-Ray Flares

Solar activity has increased to High levels with an X1.2 flare observed at 03/1139 UTC and a X1.1 flare observed at 03/2241UTC, both from AR3947 in the the northeast disk.

There are fourteen sunspot regions on the Earth-facing disc. Despite the large number of spots on the facing-disc, many are small and generally magnetically simple. AR3947 in the far northeast has been responsible for the bulk of recent activity, with two lower X-class flares now recorded. This region contains a number of moderately sized spots of potentially mixed polarity. Given its current location on the disc precise analysis remains difficult but a Mt Wilson Beta-Delta classification has been tentatively given and further changes to classification possible in the coming days. AR3944,AR3943 and AR3945 all present a risk of flares approaching the south-centre disc, although so far only limited activity observed.

GOES16 SUVI 171 imagery indicates notable magnetic looping at the southeast limb and there is recent evidence of a sunspot rotating into view in magnetogram imagery. This region may yet display further complexity as it continues to rotate onto the visible disk, this would be supported by recent far-sided helio-seismic data. Some minor sunspot arrivals signalled by recurrence into the period with would balance the lose of some smaller regions, therefore a steady risk anticipated through the period at this stage, pending further developments.

Overall, activity is forecast to be Moderate to High, with isolated M-class flares considered likely and a chance of further isolated X-flares. This risk increased given recent activity from AR3947.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	70	70
Very Active	R3-R5 (X Class)	Yes	25	25	25	25

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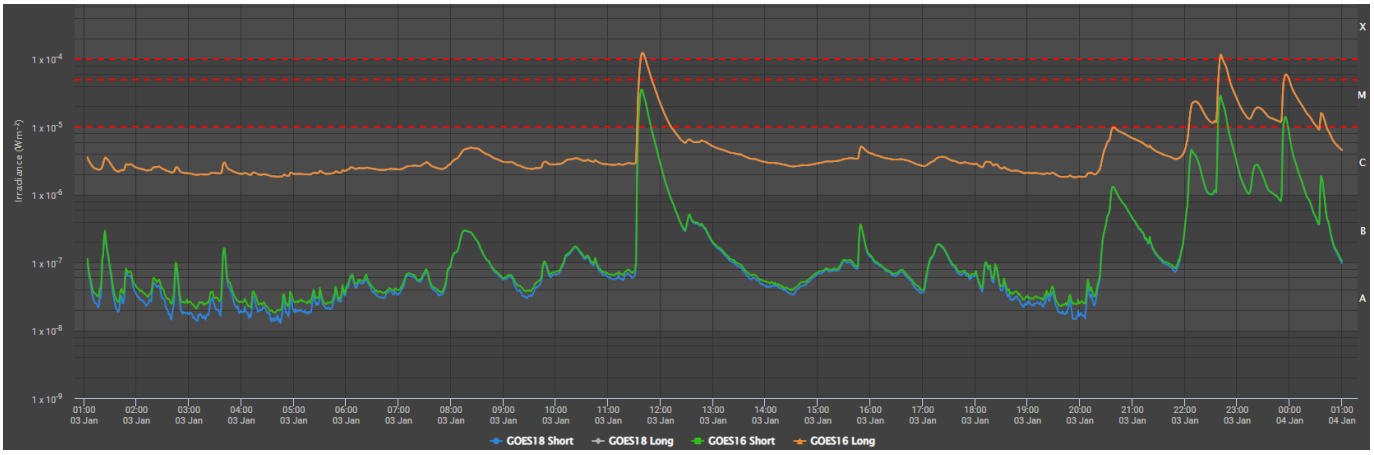
Figure 2: Latest 24hr GOES16/18 X-Ray Flare trace



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Solar Radiation Storms (High Energy Protons)

High energy proton flux as observed by GOES-18 is at background levels. Despite the large number of sunspots currently on the facing-disc there are only small contributions towards Proton Storm risks in general. There is still a chance of an enhancement in the next few days from Ex-AR3936, which rotated over the western limb on 02 Jan, should any large flares occur from this region. Overall there is a slight chance of exceeding the S1/Minor Storm threshold during the period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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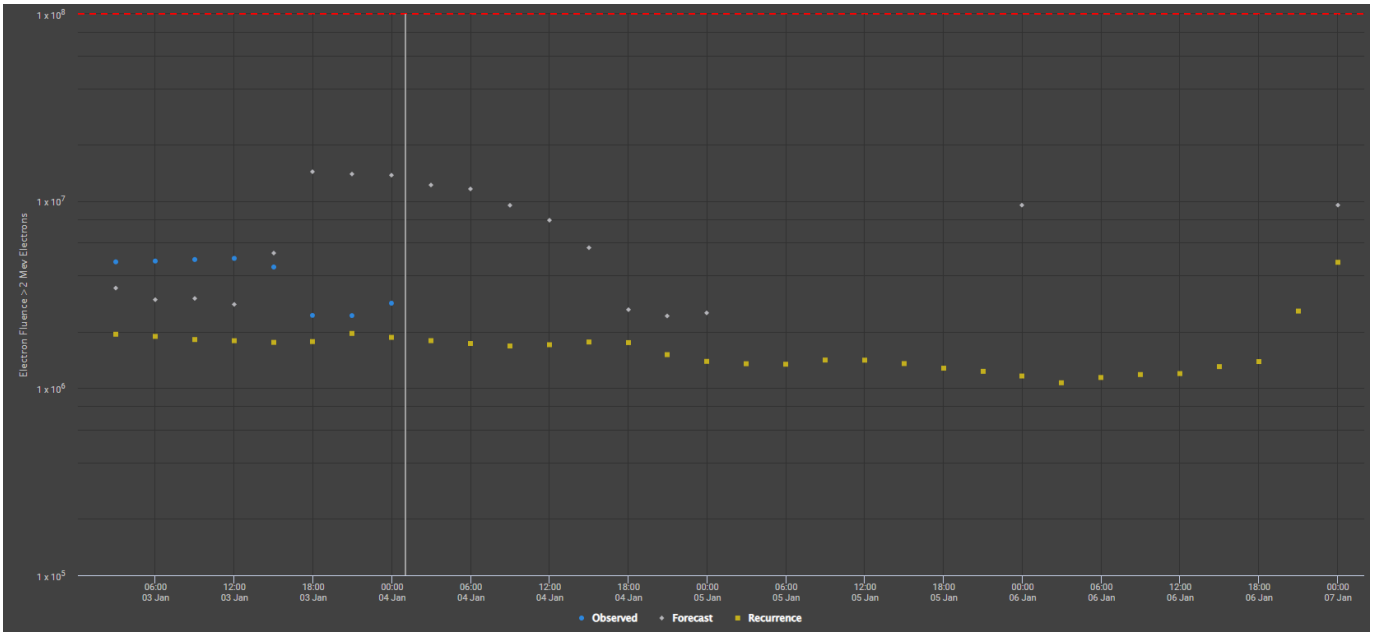
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently ranging between normal background to diurnally moderate levels. With the solar wind reducing in speed to start the period the Van Allen belt may expand back towards GEO and as a result the electron flux may to rise to moderate, possibly high levels at the diurnal max on Day 1 (04 Jan) although a potential glancing CME arrival could suppress flux values. The expected connection to the high speed stream from CH05+ late Day 1 or into Day 2 (04-05 Jan) is forecast to bring elevated, or perhaps strong solar winds, this is expected to act to suppress the radiation belt away from GEO causing the electron flux to return to background levels through the remainder of the period.

Overall the associated 24-hour fluence is expected to persist below Active levels throughout, despite a rising trend possible briefly on Day 1 (04 Jan). MOSWOC REFM output looks to be providing reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 3: Latest MOSWOC REFM output



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